Bacteria Battery

Written By: Ashley Franks

TOOLS:

- Drill (1)
  (optional) if drilling your own lids
- Multimeter (1)
  (optional) for testing power
- Pair of Rubber Gloves (1)
- Shovel or Trowel (1)
- Wire strippers (1)
  (optional) if not using pre-stripped wires from the kit

PARTS:

- MudWatt MFC Kit (1)
  Item #MKKT01 from Maker Shed, $45. Includes all materials below, except mud. You can also build MFCs from scratch, minus the Hacker Board.
- Container (1)
- Grommet (2)
  sized to seal marine wire through holes drilled in container lid
- MuddWatt Hacker Board (1)
  includes voltage-boosting chip, 8-pin socket, 22µF capacitor, resistors, and red LED that blinks when bacteria generate power. (NOTE: some of the photos show the MuddWatt Explorer board instead.)
- Mud (1)
  Almost any mud with organic compounds will work. Try freshwater ponds or streams, brackish swamps and inlets, or saltwater marshes. Try to find

mud that bubbles when disturbed or smells like rotten eggs — both are good indicators of anaerobic bacteria (but don't worry, your MFC won't smell). You can also use soil (just dig down a foot) or compost from the warm middle of a heap.

- Marine Wire (2 lengths)
  Using 2 different colors helps.

SUMMARY

Microorganisms often get a bad name because some of them cause disease. But many have useful abilities, from making beer, cheese, and wine to processing waste and cleaning up toxic chemicals. One type of bacteria, discovered in 1987 by Derek Lovley, can generate electricity. Here's how you can find bacteria like these in a local pond and put them to work.

Most non-photosynthesizing bacteria, like all animals, get their energy from the cellular respiration process, which converts glucose and oxygen to water and carbon dioxide. Oxygen works as an oxidizer, which means it accepts electrons as it combines with other chemicals in reactions. But special bacteria underground have no oxygen to breathe. Instead, they produce energy for their growth by transferring electrons to clumps of rust and other surrounding metal oxides, in a process called dissimilatory metal reduction. We now know that these electric bacteria are found in mud virtually everywhere on Earth, as well as in soil and compost heaps.

A microbial fuel cell (MFC) does the same thing as a battery: drive electrons from an anode to a cathode through chemical oxidation/reduction reactions. What makes MFCs different is that they run on organic substrate and bacteria.

"Metal-breathing" (Geobacter) bacteria at the anode carry out the oxidation reaction, converting plant and animal debris in the mud into electricity and carbon dioxide. Electrons flow through wires to a cathode sitting in water above the mud, where they combine with oxygen to complete the circuit. The bacteria are highly efficient in this arrangement and can produce electricity continuously for many months or even years.

Experimental MFC-powered buoys now operate in the Potomac River, using naturally occurring bacteria in the mud to measure and transmit meteorological data.

These “Benthic Unattended Generators” (BUGs) have worked for several years with no decrease in power output (see http://nrl.navy.mil/code6900/bug). Geobacter species possess other useful abilities, such as the ability to respire radioactive uranium and remove it from ground water. They have proven versatile and effective in cleaning up areas contaminated with uranium or organic pollutants.

In addition to their scientific interest, MFCs are a useful educational tool: a popular science project that encompasses microbiology, chemistry, electronics, and other disciplines. That’s why Keego Technologies developed the MudWatt, a low-cost microbial fuel cell kit. They also support online discussion forums for MFC makers.

With the MudWatt, students of all ages are learning about MFCs and making scientifically relevant discoveries. For example, a 6th-grade student in Santa Cruz uncovered (literally) a river sediment that produces twice as much power as typical topsoil.

Step 1 — Make your own MFC.

- Mix your mud (or soil or compost) to saturation with water and put a ½" layer into the bottom of your container. You can experiment by adding extra ingredients; see http://keegotech.com/community/education for ideas.
- Cut the 2 pieces of graphite fiber cloth to fit the container. Be careful not to disperse the fibers in the air because they can cause short circuits in household electrical equipment.
- Strip 4" from one end of each piece of marine wire, and weave each through a piece of graphite cloth. Strip the other ends ½" and thread each through a grommet. Drill the lid of the container to fit the grommets.

Step 2

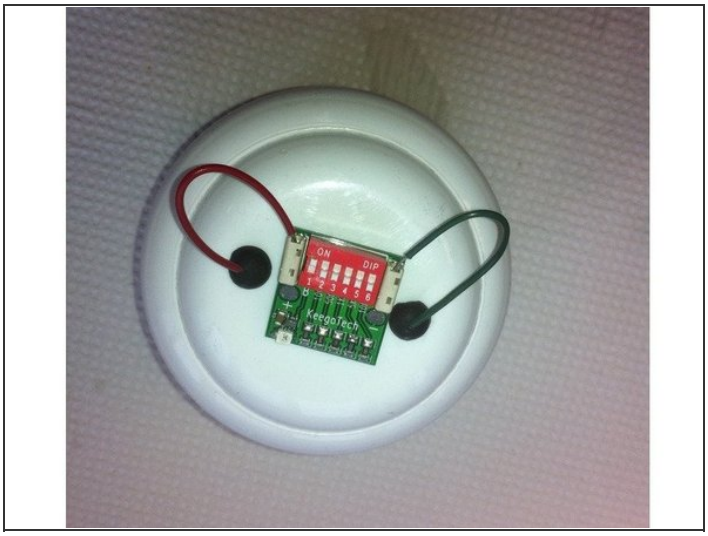
- Lay one graphite cloth on top of the mud with its wire sticking up; this will be the anode. Cover it with ½" more mud and let it settle for a few minutes.

Step 3



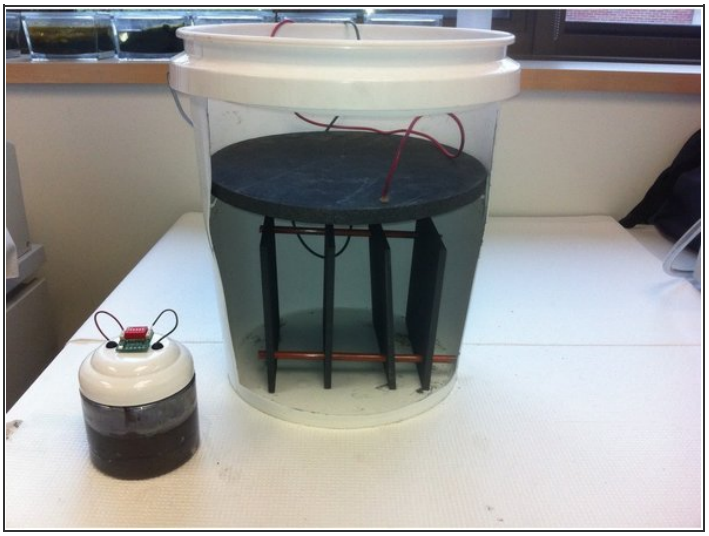
- For the cathode, place the other graphite cloth on top of the mud, with its wire also pointing up. Avoid covering the cathode cloth with any mud, and gently pour a little water on top to moisten it.
  - If the cathode doesn't sink in water (it may have air bubbles in it), try putting a few small rocks on it to keep it from floating.
- Close the container, sealing the grommets into the holes in the lid such that the wires stick out. It may help to gently twist the wires counterclockwise one turn before screwing on the top.

Step 4



- Attach the 2 wires to the MudWatt Hacker Board’s 8-pin socket: anode to the (–) pin and cathode to the (+) pin.
- Attach the Hacker Board to the lid of your container using the provided adhesive pad.

Step 5 — Microbe Power



- Within 3–10 days, the MFC will generally produce enough power to make the LED blink; the more power, the faster the blinking. Keep your MFC warm and moist inside to help the bacteria grow and produce the most power.
  - Try adding a very small amount of table salt to the water to increase conductivity if the voltages are too low.
- The MudWatt Hacker Board boosts the bacteria's power to 2.4 volts, and its 8-pin socket lets you change a resistor value in the blinker circuit to optimize power to the LED. You can also power other devices that run on 3V or less. Download the instructions at http://keegotech.com/community/Hacker_Bo... and see http://keegotech.com/forum for more ideas.
- Power generated by an MFC is a product of its electrode surface area, so once you have your first one running, don't be afraid to go large.
- By simply configuring 2 electrodes correctly in mud, soil, or compost, anyone anywhere can harness naturally occurring bacteria to provide continuous, non-polluting, carbon-neutral electricity.

This project first appeared in MAKE Volume 30, page 140.

This document was last generated on 2012-10-30 07:00:38 PM.